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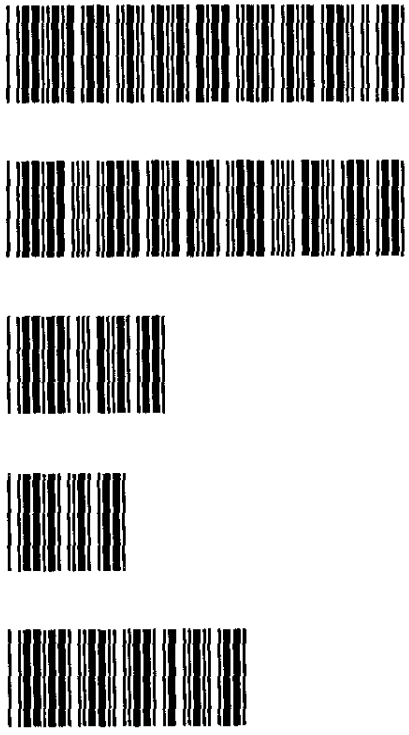

TELIOS PHARMACEUTICA

MERCK KGAA

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CMP.

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ORIGINAL

UNITED STATES DISTRICT COURT

FOR THE SOUTHERN DISTRICT OF CALIFORNIA

TELIOS PHARMACEUTICALS, INC., a Delaware corporation, and THE BURNHAM INSTITUTE, a California nonprofit corporation,

Plaintiffs,

vs.

MERCK KGaA, a German corporation, THE SCRIPPS RESEARCH INSTITUTE, a California nonprofit corporation, DR. DAVID A. CHERESH, a California citizen, and DOES 1-25 inclusive,

Defendants.

Civil Action No.

'96 1 [illegible]

COMPLAINT FOR PATENT INFRINGEMENT

Plaintiffs, for their complaint herein allege as follows:

1. Plaintiff Telios Pharmaceuticals Inc. ("Telios") is a corporation incorporated under the laws of Delaware with its principal office and place of business at 11045 Roselle Street, Suite A, San Diego, California 92121.

2. Plaintiff The Burnham Institute, formerly known as the La Jolla Cancer Research Foundation, is a nonprofit corporation incorporated under the laws of the state of California with its principal place of business at 10901 North Torrey Pines Road, La Jolla, California 92037.

3. Upon information and belief, Defendant Merck KGaA is a corporation incorporated under the laws of Germany and with its principal place of business at Frankfurter Strasse 250, 64271 Darmstadt, Germany.

4. Upon information and belief, Defendant The Scripps Research Institute ("TSRI") is a nonprofit corporation incorporated under the laws of the State of California with its principal place of business at 10666 North Torrey Pines, Road, La Jolla, California 92037.

5. Upon information and belief, Defendant David A. Cheresh, Ph.D., is a natural person who is a citizen of California and who resides in the City of San Diego, California. Dr. Cheresh has worked and continues to work as a researcher for Defendant TSRI.

JURISDICTION AND VENUE

6. This action arises under the patent laws of the United States of America and jurisdiction is founded on Title 28, United States Code, §§ 1331 and 1338(a).

7. Venue is proper in this Court under Title 28, United States Code, § 1400(b).

CLAIMS

8. On December 20, 1988, United States Patent No. 4,792,525 (the "'525 Patent"), a copy of which is attached hereto as Exhibit A, was duly and legally issued to the La Jolla Cancer Research Foundation, now known as The Burnham Institute, as sole assignee of all rights in said patents from inventors Erkki Ruoslahti, Ph.D., and Michael Pierschbacher, Ph.D. The Burnham Institute, which is the sole owner of the '525 Patent, has exclusively licensed all rights in said patent

to Telios. Pursuant to said exclusive license, Telios has the right to sue and to recover for infringement of the '525 Patent.

9. Upon information and belief, Defendant Merck KGaA, with actual knowledge of the '525 Patent, has willfully and deliberately induced, and continues to willfully and deliberately induce, Defendants TSRI and David A. Cheresh, Ph.D., to infringe the '525 Patent. Upon information and belief, Merck KGaA has provided, and continues to provide, TSRI and Dr. Cheresh with financial and other support for their past and presently ongoing scientific research involving the use of compounds and methods that infringe the '525 Patent. Upon information and belief, in exchange for such support, Merck KGaA has received and/or will receive exclusive access and rights to scientific data and information relating to and derived from the induced infringing scientific research by TSRI and Dr. Cheresh, as well as to any inventions derived from said infringing research. Defendant Merck KGaA knew or should have known that such an agreement or arrangement would induce Defendants TSRI and Dr. David A. Cheresh to infringe the '525 Patent.

10. Upon information and belief, Defendant Merck KGaA, with actual knowledge of the '525 Patent, has in the past and continues to willfully and deliberately infringe the '525 Patent and/or contribute to said infringement by importing compounds claimed in said patent into the United States and this District without the authority of the Plaintiffs and in violation of Title 35, United States Code, § 271, and will continue to do so unless enjoined by this Court.

11. Upon information and belief, Defendants TSRI and Dr. David A. Cheresh, with actual knowledge of the '525 Patent, have willfully and deliberately infringed, and continue to willfully and deliberately infringe, the '525 Patent and/or contribute to and/or induce said infringement in the United States and within this District, without the authority of the Plaintiffs, and in violation of Title 35 United States Code, § 271, and will continue to do so unless enjoined by this Court.

12. Plaintiffs have suffered damage by reason of the infringement and inducement of infringement of the '525 Patent by Defendants and will suffer additional irreparable damage and impairment of the value of its patent rights unless Defendants are enjoined by this Court from continuing their infringement and inducement of infringement of the '525 Patent.

13. The acts of infringement and inducement of infringement by Defendants have been and are being committed with full knowledge of Plaintiffs' rights under the '525 Patent, and with willful and wanton disregard thereof, rendering this an exceptional case under Title 35 United States Code, § 285.

WHEREFORE, Plaintiffs pray that:

a. Defendants be adjudged and decreed to have infringed and induced infringement of the '525 Patent;

b. A preliminary and permanent injunction issue restraining and enjoining said Defendants, their officers, agents, attorneys and employees, and those acting in privity or concert with them, and each of them, from further infringement and inducement of infringement of the '525 Patent;

c. Defendants be ordered to account for damages adequate to compensate Plaintiffs for Defendants' infringement and inducement of infringement, together with prejudgment interest;

d. Such damages be trebled by the Court pursuant to Title 35, United States Code, § 284, by reason of the willful, wanton and deliberate nature of such infringement and inducement of infringement;

e. This be decreed an "exceptional case" within the meaning of Title 35, United States Code, § 285, and reasonable attorney's fees be awarded to the Plaintiffs;

f. Costs be awarded to Plaintiffs; and

g. Plaintiffs be granted such other and further relief as the Court may deem proper under the circumstances.

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DEMAND FOR JURY TRIAL

Plaintiffs hereby request a trial by jury.

Respectfully Submitted,

CAMPBELL & FLORES LLP
MAURICIO A. FLORES
LYNNE M. BRENNAN
CALVIN A. FAN

Dated: July 18, 1996

By: _____
Mauricio A. Flores
Attorneys for Plaintiffs
TELIOS PHARMACEUTICALS, INC. and
THE BURNHAM INSTITUTE

A

United States Patent [19]

Ruoslahti et al.

[11] **Patent Number: 4,792,525**

[45] **Date of Patent: * Dec. 20, 1988**

[54] **TETRAPEPTIDE**

[75] Inventors: **Erkki Ruoslahti**, Olivenhain; **Michael Pierschbacher**, San Diego, both of Calif.

[73] Assignee: **La Jolla Cancer Research Foundation**, La Jolla, Calif.

[*] Notice: The portion of the term of this patent subsequent to Mar. 25, 2003 has been disclaimed.

[21] Appl. No.: **744,981**

[22] Filed: **Jun. 17, 1985**

Related U.S. Application Data

[60] Division of Ser. No. 554,821, Nov. 22, 1983, Pat. No. 4,578,079, and a continuation-in-part of Ser. No. 405,239, Aug. 4, 1982, Pat. No. 4,517,686, and a continuation-in-part of Ser. No. 433,457, Oct. 8, 1982, abandoned, and a continuation-in-part of Ser. No. 518,036, Jul. 28, 1983, Pat. No. 4,589,881.

[51] **Int. Cl.**[4] C12N 0/500; C12N 11/08; C07K 7/10; C07K 17/02

[52] **U.S. Cl.** **435/240.243**; 435/180; 530/811; 530/330; 530/324; 530/812; 530/815

[58] **Field of Search** 435/240, 241, 244, 180; 530/815, 330, 353, 380

[56] **References Cited**

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Primary Examiner—John E. Tarcza
Attorney, Agent, or Firm—Pretty, Schroeder, Brueggemann & Clark

[57] **ABSTRACT**

The peptide X-Arg-Gly-Asp-R-Y wherein X is H or at least one amino acid and Y is OH or at least one amino acid, and R is an amino acid selected from Thr or Cys, or other amino acid, having the same cell-attachent activity as fibronectin and the peptide X-Arg-Gly-Asp-Ser-Y, wherein X and Y, having said activity are disclosed.

11 Claims, 2 Drawing Sheets

CODE	SEQUENCE	CELL ATTACHMENT
FIBRONECTIN		0.10 nmol/ml (+ + + +)
IV	Y A V T G R G D S P A S S K P I S I N Y R T E I D K P S Q M(C)	0.25
IVA	V T G R G D S P A S S K P I (C)	1.6
IVB	S I N Y R T E I D K P S Q M(C)	> 50.0
IVA1	V T G R G D S P A (C)	2.5
IVA2	S P A S S K P I S (C)	> 50.0
IVA1a	V T G R G D (C)	10.0
IVA1b	G R G D S (C)	3.0
IVA1c	R G D S P A (C)	6.0
RVDS	R V D S P A (C)	> 50.0
TGRG	T G R G	—
RGDS	R G D S	+ +
GDSP	G D S P	—

EXHIBIT A

CODE	SEQUENCE	CELL ATTACHMENT 0.10 nmol/ml (+ + + + +) 0.25
FIBRONECTIN		
IV	YAVTGRGDSPASSKPISINYRTEIDKPSQM(C)	1.6
IVA	VTGRGDSPASSKPI(C)	> 50.0
IVB	SINYRTEIDKPSQM(C)	2.5
IVA1	VTGRGDSPA(C)	> 50.0
IVA2	SPASSKPIS(C)	10.0
IVA1a	VTGRGD(C)	3.0
IVA1b	GRGDS(C)	6.0
IVA1c	RGDSPA(C)	> 50.0
RVDS	RVDSPA(C)	—
TGRG	TGRG	+ +
RGDS	RGDS	—
GDSP	GDSP	

Fig. 1

EXHIBIT A

A) PROTEINS	SEQUENCE	CELL ATTACHMENT
Fibronectin	A V T G R G D S P A S S K	Active
Fibrinogen α chain	T S Y N R G D S T F E S K	Active
λ receptor on E. coli	G S F G R G D S D E W T F	NT§
Sindbis coat protein	G V G G R G D S G R P I M	NT
α lytic protease	A C M G R G D S G G S W I	NT
Testis-specific basic protein	K S R K R G D S A D R N Y	NT
B) Collagens:		
α_2 (I) T	A P G L R G D T G A T G R	Active
α_2 (I) K	P Q G I R G D K G E P G E	Inactive
α_1 (IV) P	D X G S R G D P* G T P* G V	Inactive
α_1 (II) KE	A P* G V K G E S G S P G S	Inactive

§ Not Tested

* 4-hydroxyproline

Fig. 3

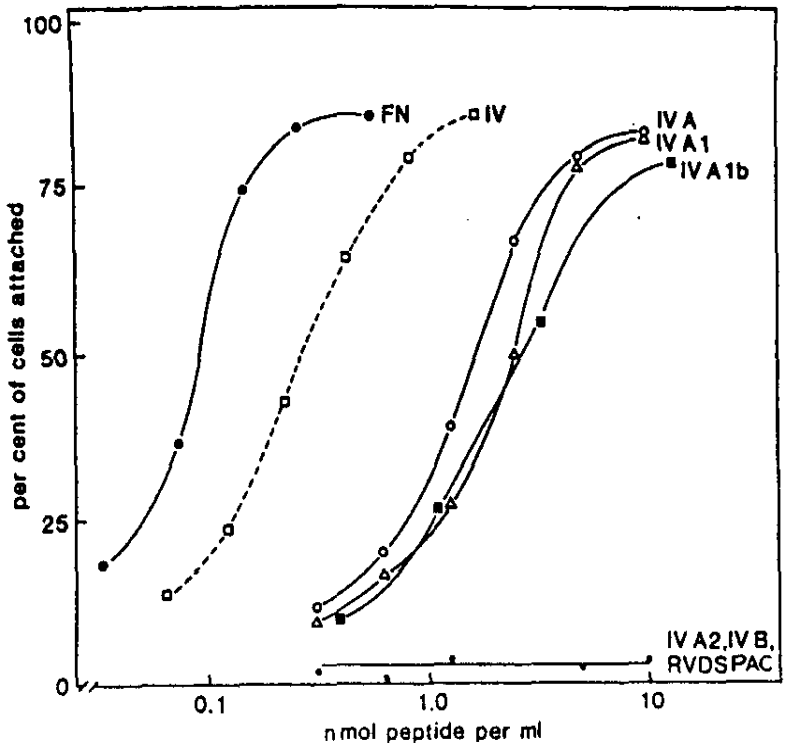

Fig. 2

EXHIBIT A

TETRAPEPTIDE

This invention was made with government support under CA 28896 and CA 30199 awarded by the National Cancer Institute. The government has certain rights in this invention.

This application is a division of application Ser. No. 554,821 filed Nov. 22, 1983, now U.S. Pat. No. 4,578,079 and this application is a continuation-in-part of our earlier applications filed Aug. 4, 1982 (Ser. No. 405,239), now U.S. Pat. No. 4,517,626 Oct. 8, 1982 (Ser. No. 433,457), and July 28, 1983 (Ser. No. 518,036), now U.S. Pat. No. 4,389,881 and is a continuation of application Ser. No. 554,821, filed Nov. 22, 1983, now U.S. Pat. No. 4,578,079.

This invention is directed to polypeptides related to fibronectin and more particularly to a polypeptide segment of human fibronectin which interacts with cell surfaces. In particular, the invention promotes cell attachment to substrates on which the peptide segment is immobilized, and inhibits cell attachment when presented in solubilized form.

BACKGROUND OF THE INVENTION

Fibronectin is a large glycoprotein, about 450 thousand daltons, which is composed of several apparently independent functional domains. Fibronectin was earlier discovered as a major extracellular matrix protein, and it was demonstrated that it would interact in vitro with other structural molecules, such as collagen, glycosaminoglycans, proteoglycans, fibrinogen, fibrin, and actin, as well as with cell surfaces. It was discovered that fibronectin promotes the attachment of suspended cells to collagen and also that it promotes the attachment of suspended cells directly to tissue culture substrate, independent of its binding to collagen. Accordingly, investigation continued with respect to the region of the fibronectin molecule that interacts with cell surfaces.

Earlier, a polypeptide fragment of fibronectin which embodies the cell attachment activity of fibronectin was isolated, purified and characterized as a 11.5 kDal polypeptide of 108 amino acid residues, and having the formula: H-Ile-Gly-Gln-Gln-Ser-Thr-Val-Ser-Asp-Val-Pro-Arg-Asp-Leu-Glue-Val-Val-Ala-Ala-Thr-Pro-Thr-Ser-Leu-Leu-Ile-Ser-Trp-Asp-Ala-Pro-Ala-Val-Thr-Val-Arg-Tyr-Tyr-Arg-Ile-Thr-Tyr-Gly-Glu-Thr-Gly-Gly-Asn-Ser-Pro-Val-Gin-Glu-Phe-Thr-Val-Pro-Gly-Ser-Lys-Ser-Thr- la-Thr-Ile-Ser-Gly-Leu-Lys-Pro-Gly-Val-Asp-Tyr-Thr-Ile-Thr-Val-Tyr-Ala-Val-Thr-Gly-Arg-Gly-Asp-Ser-Pro-Ala-Ser-Ser-Lys- Pro-Ile-Ser-Ile-Asn-Tyr-Arg-Thr-Glu-Ile-Asp-Lys-Pro-Ser-Gln-Met-OH. Also, a fragment of the foregoing molecule having the same cell attachment activity was synthesized and is comprised of 30 amino acid residues having the formula: H-Tyr-Ala-Val-Thr-Gly-Arg-Gly-Asp-Ser-Pro-Ala-Ser-Ser-Lys-Pro-Ile-Ser-Ile-Asn-Tyr-Arg-Thr-Glu-Ile-Asp-Lys-Pro-Ser-Gln-Met-OH. (These fragments have been described in the aforesaid patent applications.) These polypeptides, or a fragment thereof which has cell attachment-activity, can be used to prepare substrates to which cells will attach. Such substrates are useful in cell culture dishes and are also useful for employment in medical prosthetic devices for implantation in the human body where enhanced cell attachment to the surface is desirable.

SUMMARY OF THE INVENTION

Here we wish to describe the precise localization of this function of the fibronectin molecule as a tetrapeptide sequence. This sequence or a chemically similar, biologically equivalent, sequence is shared by some other proteins which interact with cells. These include collagen, fibronogen and surface proteins of *E. coli* bacteria and Sindbis virus. These findings suggest that the mechanism by which cells attach to a fibronectin-containing substrate may be only one instance of a widely general recognition system that cells use to adhere to any number of substrates. This mechanism may also be involved with a cell's phagocytic activity. Further, it also appears possible that bacteria and possibly even certain viruses may take advantage of this universal cellular adhesion mechanism to gain entry into the body or the cell.

The present invention contemplates a new composition, a polypeptide which alters the cell attachment activity of cells to various substrates independent of its binding to collagen, affects cell phagocytosis, and which consists essentially of an isolated tetrapeptide X-Arg-Gly-Asp-Ser-Y wherein X is H or one or more amino acids and Y is OH or one or more amino acids. The tetrapeptide composition is characterized in that it is substantially isolated from fibronectin, either by separation from fibronectin or by synthesis wherein fibronectin was never present, and has substantially the same cell attachment activity as fibronectin. In defining the tetrapeptide, there is some variability in one of the amino acids. While Arg-Gly-Asp-Ser is the preferred form of the tetrapeptide of this invention, it may include other amino acids additionally or in a limited sense in substitution for one or omre of the amino acids, such as for Ser, Arg-Gly-Asp-Cys or Arg-Gly-Asp-Thr which exhibit a similar cell attachment activity. Chemical moieties may be included at either end, typically at the —COOH end, of the tetrapeptide for the purpose of immobilizing the peptide, or, amino acid additions may be used to modify the cell attachment activity. Also, the invention may be incorporated as part of a larger molecule.

The present invention also contemplates the method of using these compositions to promote cell attachment to a substrate wherein the invention is immobilized on the substrate.

The present invention additionally contemplates the method of using the invention in a solubilized or suspended form to inhibit undesirable cell attachment to a substrate or to each other, and to enhance the phagocytic activity of the cells.

DESCRIPTION OF THE DRAWINGS

FIG. 1 lists the polypeptides, and their respective amino acid sequence and relative cell attachment acitivity in concentrations necessary to achieve half-maximal activity, that were synthesized in determining the smallest peptide exhibiting cell attachment activity.

FIG. 2 compares cell attachment activity of selected synthesized polypeptides from FIG. 1 with fibronectin (FN).

FIG. 3 lists the proteins occurring naturally containing substantially the tetrapeptice sequence of amino acids, the fragment sequence synthesized (in bold type) containing the active site, and the cell attachment activity if tested.

EXHIBIT A

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Abbreviations for Amino Acids

Amino Acid	Three-letter abbreviation	One-letter symbol
Alanine	Ala	A
Arginine	Arg	R
Asparagine	Asn	N
Aspartic acid	Asp	D
Cysteine	Cys	C
Glutamine	Gln	Q
Glutamic acid	Glu	E
Glycine	Gly	G
Histidine	His	H
Isoleucine	Ile	I
Leucine	Leu	L
Lysine	Lys	K
Methionine	Met	M
Phenylalanine	Phe	F
Proline	Pro	P
Serine	Ser	S
Threonine	Thr	T
Tryptophan	Trp	W
Tyrosine	Tyr	Y
Valine	Val	V

The nomenclature used to define the polypeptide is that specified by Shroder & Lubke, "The Peptides", Academic Press (1965) wherein, in accordance with conventional representation the N-terminus appears to the left, and the C-terminus appears to the right. Where the amino acid residue has isometric forms, it is the L-form of the amino acid that is represented.

The invention provides a polypeptide having the following formula: H-Arg-Gly-Asp-Ser-OH and is intended to includes other polypeptides or substances containing this formula as well as polypeptides formed from the invention by limited substitution or deletion and which have cell attachment activity. (Cell attachment activity hereinafter includes cell attachment promoting activity, phagocytic activity, and the inhibition of cell attachment.) Moreover, the coupling of the peptide to substrates may be faciliated in certain instances, without affecting the cell attachment activity, by adding a Cys residue at the C-terminus. Further, the cell attachment activity may be modulated by variable additions to the C- and/or N-termini.

The invention, or a larger polypeptide or other molecule including the invention, can be synthesized by any suitable method, such as by exclusively solid-phase techniques, by partial solid-phase techniques, by fragment condensation, or by classical solution addition. It is also envisioned that a hybrid protein with adhesive or cell attachment properties could be generated by combining the peptide of the invention with another protein. Moreover, using recently developed recombinant DNA techniques, the invention may be synthesized singularly, or combined with another protein by first including the DNA code of the invention in the code of the desired protein.

Source of Peptides

The peptides are preferably prepared using solid phase synthesis, such as that described by Merrifield, *J. Am. Chem. Soc.*, 85, 2149 (1964), although other equivalent chemical synthesis known in the art, as mentioned above, can also be used. Solid-phase synthesis is commenced from the C-terminus of the peptide by coupling a protected alpha-amino acid to a suitable resin, as generally set forth in U.S. Pat. No. 4,244,946, issued Jan. 21, 1982 to Rivier et al., the disclosure of which is incorporated herein by reference. Examples of synthesis of this general type are set forth in U.S. Pat. Nos. 4,305,872 and 4,316,891. Discussion of the solid-phase synthesis of a 41-residue polypeptide is set forth in *Science*, 213, 1394–1397 (September 1981) in an article by Vale et al., which refers to a more detailed discussion of the synthesis, which appears in an article by Marki et al. in *J. Am. Chem. Soc.*, 103, 3178 (1981).

In order to locate the cell attachment activity of the fibronectin molecule which would possibly be contained within a hydropholic stretch of amino acids in the 30-amino acid synthetic peptide described above, a number of peptides were synthesized using the Merrifield procedure by Peninsula Laboratories (Belmont, CA), and included, in most cases, a COOH-terminal cystine. The design was to selectively synthesize peptides smaller than a previous fragment exhibiting cell attachment activity. As can be clearly seen in FIG. 1, this approach permits the determination of the smallest fragment showing activity.

Cell Attachment Promoting Activity

Those peptides having a COOH-terminal cystine residue were assayed for their activity in promoting cell attachment by first attaching them via the heterobifunctional crosslinker SPDP (N-succinimidyl 3-(-2-pyridyldithio) propionate, Sigma, St. Louis, Mo.) to rabbit IgG which was immobilized on plastic. The attachment assay was then carried out as described by Ruoslahti, E. et al., Methods Enzymology 82:803–831 (1981) using freshly trypsinized normal rat kidney cells (NRK). After a one hour incubation, those cells which had attached were fixed, stained and quantitated using either an Artek cell counter or a multiscan spectrophotometer. In all cases, maximum attachment was about 80–90% of the cells plated. The relative activity of each peptide is indicated by the concentration of the peptides in nmoles/ml necessary to achieve half-maximal activity, or, where accurate quantitation was not possible, by the crosses at the right of FIG. 1, and by the graph in FIG. 2.

Among the peptides tested, the tetrapeptide Arg-Gly-Asp-Ser was the smallest one and the only tetrapeptide which, when properly immobilized, had the property of causing cell attachment. The activity of the peptides decreased somehwat with size (FIG. 2). This decrease may be due to a decrease in the stability of their conformation or to a relative inaccessibility on the substrate. The serine residue could be replaced by a cysteine residue without complete loss of the activity of the peptide. When the arginine or aspartic acid residues were selectively deleted, however, the activity was lost. Moreover, substitution of the glycine with the bulky valine residue also abolished the activity (RVDSPAC. FIG. 1). Whereas these results show that the residues critical for the activity reside in the tetrapeptide sequence, amino acids immediately flanking the four residue fragment may have a modulatory effect on their activity.

It appears that while the tetrapeptide described is the determinant, optimum size of the polypeptide is about a hexapeptide which includes the defined tetrapeptide. Thus, the invention consists essentially of the tetrapeptide which would preferably be part of a hexapeptide.

Arg-Gly-Asp-Ser and Related Sequences in Other Proteins

Having established the importance of the tetrapeptide sequence, a computer search through the published

protein sequences was conducted by the National Biomedical Research Foundation (George Washington University Medical Center, Washington, D.C.). Also included were sequences in which the serine was allowed to be replaced by other amino acids, and the arginine and aspartic acid by the chemically similar lysine and glutamic acid, respectively. The search through other proteins revealed five proteins having the Arg-Gly-Asp-Ser sequence (FIG. 3).

Of the five proteins having the identical four amino acid sequence, fibrin(ogen) is of most obvious interest because of its demonstrated interaction with fibronectin and cell surfaces. For this reason, a synthetic nonopeptide designed after the fibrin sequence was tested. As can be seen in FIG. 3, it two was an active cell attachment promoter. Attempts to demonstrate the attachment of test cells to intact fibrinogen or fibrin have given no clear-cut results, although platelets do bind to the fibronogen molecule.

Among the remaining proteins that possess sequences related to the active tetrapeptide, the family of collagenous proteins is of particular interest for two reasons. First, collagens have been shown to mediate cell attachment independently of fibronectin, and, secondly, variations of the tetrapeptide sequence are particularly abundant in collagens. These sequences are repeated at fairly regular intervals along the α_1 and α_2 chains of type I collagen.

Four synthetic peptides were prepared based on diverse sequences in collagen. In three of these, the serine residue was replaced by threonine, hydroxyproline, or lysine, respectively. In the fourth one a lysine was substituted for arginine and glutamic acid for aspartic acid. Of these peptides only the serine to threonine substitution was active with the NRK test cells (FIG. 2). Other chemically similar substitutions such as serine to alanine may also yield active sites.

The results show that the primary cell-binding site of the fibronectin molecule resides in an extremely short amino acid sequence which is shared by at least one other adhesive protein, collagen. Because of the nature of the proteins having the tetrapeptide sequence among the proteins searched, the results suggest that the tetrapeptide with selected substitutions, may represent a universal attachment mechanism.

Inhibition of Cell Attachment

If the mechanism of cell attachment involves the recognition of the amino acid sequence of the tetrapeptide by a receptor on the cell, then it could be postulated that attachment could be inhibited by preventing this recognition by "blocking" the receptor. To demonstrate this inhibitory function of the invention, fibronectin was immobilized on a substrate to be tested for cell attachment activity. In separate experiments, various concentrations of the tetrapeptide (Arg-Gly-Asp-Ser) and a hexapeptide, Pro-Arg-Gly-Asp-Ser-Gly in a solubilized form were combined with the free cells, and attachment activity measured as above. Both peptides were shown to inhibit the normal attachment of cells to a fibronectin-coated substrate when placed in a solubilized form in combination with the free cells. The concentration necessary to exhibit half-maximal cell inhibition activity waws 0.6–0.8 moles/ml and 0.3 mmoles/ml for the tetrapeptide and the hexapeptide, respectively.

Enhanced Phagocytic Activity

Fibronectin has been shown to promote phagocytosis, and this activity has been linked to the cell attachment activity. An application that can be envisioned for the invention based on these observations is to promote the entrance to cells of particles containing, for example, a therapeutic agent, by administering the particles with the invention in a solubilized form.

Practical application such as the preparation of surfaces for optimal cell culture, the derivatization of various prosthetic materials to promote bonding with surrounding tissues, a method to provide for the increased internalization of molecules such as toxins, drugs, hormones, or the like by the enhancement of phagocytosis, and the development of ways of manipulating cellular adhesion mechanisms in diseases such as cancer metastasis and platelet aggregation can also be envisioned. Since a peptide of four amino acids is unlikely to have more than one binding site, one question that can be addressed now is whether the interaction of all types of cells with fibronectin involves this same region of the molecule. Platelets, for example, may bind fibronectin on their surfaces by a different mechanism. This would be important in using this peptide to regulate cell attachment or in the design of prosthetic materials. It would also shed light on the role played by fibronectin in vivo.

In particular, the coating of the culture substrate with the cell-attachment polypeptide obviates the use of fibronectin in the medium, thus providing bette define conditions for the culture as well as better reproducibility. As one example of commercial use of cell-attachment surfaces. Cytodex particles, manufactured by Pharmacia, are coated with gelatin, making it possible to grow the same number of adherent cells in a much smaller volume of medium than would be possible in dishes. The activity of these heads is generally dependent upon the use of fibronectin in the growth medium, and the cell-attachment polypeptide is expected to provide an improved, chemically-defined coating for such purposes. Other surfaces or materials may be coated to enhance attachment, such as glass, agarose, synthetic resins, or long-chain polysaccharides.

Medical devices can be designed making use of such substrata to attract cells to the surface in vivo or even to promote the growing of a desired cell type on a particular surface prior to grafting. An example of such an approach is the induction of endothelial cell growth on a prosthetic blood vessel or vascular graft, which is generally woven or knitted from nitrocellulose or polyester fiber, particularly Dacron (polyethylene terephthalate) fiber. Most types of cells are attracted to fibronectin and to this polypeptide, but endothelial cells and fibroblastic cells in particular are attracted to fibronectin. The latter point indicates the potential usefulness of this defined polypeptide in coating a patch graft or the like for aiding wound closure and healing following an accident or surgery. In such cases, it may be advantageous to couple the peptide to a biological molecule, such as collagen, a glycosaminoglycan or a proteoglycan; for example, the five-residue fragment having a Cys-residue at the C-terminus coupled to monomeric collagen by using a crosslinker such as 3-(2-pyridyldithio) propionic acid N-hydroxysuccinimide ester to effect cross-linking of the cystein to a lysine residue in the collagen, or by using carbodiimide without the Cys on the four-resins fragment. It is also indicative of its value in coating surfaces of a prosthetic device which is intended to serve as a temporary or semipermanent entry into the body, e.g. into a blood vessel or into the peritoneal cavity, sometimes referred to as a percutaneous device. Fibronectin has been shown to be chemotactic to fibroblasts and macrophages. This activity

correlates with the presence of the cell attachment domain. One potential manifestation of the cell attachment activity of the synthetic peptides described here, and fragments thereof of like characteristics, is chemotactic activity.

Application of the ability of the invention to inhibit cell attachment when presented in a solubilized form may find utility in situations where it is desirable to prevent cell adhesion to a substrate or adhesion between cells. Undesirable cell attachment to various medical sutures, or dressings, may be prevented by presenting the invention in solubilized form. When the invention is used either in conjunction or combination with anothe molecule, such as a therapeutic agent, or particle treated with such an agent, the entrance of that agent or particle into the cell may be enhanced by the effect of the invention on the phagocytic activity of the cell, thereby increasing the efficiency of the therapeutic agent.

Although the invention has been described with regard to certain preferred embodiments, it should be understood that various changes and modifications, as would be obvious to one having the ordinary skill in this art, may be made without departing from the scope of the invention which is defined in the appended claims. For example, it may not be necessary to have the free acid at the C-terminus, as it may be amidated or substituted by some other group. Further, limited substitutions may be made to the basic tetrapeptide as illustrated by the substitution of Ser by Cys, without destroying the inherent cell attachment activity. Particular features of the invention are emphasized in the claims which follow.

Industrial Application

The invention is useful in surgery and therapeutic reconstruction and treatment of injuries.

What is claimed is:

1. A method for promoting cell attachment to a substrate comprising the steps of:

immobilizing on the substrate a non-naturally occurring polypeptide which includes as the cell-attachment-promoting constituent the sequence -Arg-Gly-Asp-R- wherein R is Ser, Cys, Thr or other amino acid such that the polypeptide has cell-attachment-promoting activity; and providing free cells for attachment to said substrate,.

2. A method for promoting cell attachment to a substrate comprising the steps of:

immobilizing on the substrate a composition of matter comprising a non-naturally occurring peptide

X-Arg-Gly-Asp-R-Y

wherein X is H or at least one amino acid and Y is OH or at least one amino acid, and R is an amino acid selected from Ser Thr, Cys or other amino acid, such that said peptide has cell-attachmentpromoting activity; and

providing free cells for attachment to the substrate.

3. A method of promoting cell attachment activity comprising the steps of:

immobilizing on a substrate a non-naturally occurring polypeptide including the sequence Arg-Gly-Asp-Ser; and

providing free cells for attachment to said substrate.

4. A method for promoting cell attachment to a substrate comprising the steps of:

immobilizing on the substrate a substantially pure peptide including as the cell-attachment-promoting constituent the amino acid sequence Arg-Gly-Asp-R wherein R is Ser, Cys, Thr or other amino acid, said peptide having cell-attachment-promoting activity, and said peptide not being a naturally occurring peptide; and

providing free cells for attachment to said substrate.

5. A method of promoting cell attachment to a substrate, comprising the steps of:

immobilizing on the substrate a polypeptide which includes as the cell-attachment-promoting constituent the amino acid sequence Arg-Gly-Asp-R wherein R is Ser, Cys, Thr or other amino acid such that the polypeptide has cell attachment promoting activity, said polypeptide having less than about 31 amino acid residues; and

providing free cells for attachment to said substrate.

6. A method of prommoting cell attachment to a substrate, comprising the steps of:

immobilizing on the substrate a composition of matter comprising a substantially pure polypeptide

X-Arg-Gly-Asp-R-Y

wherein X is H or at least one amino acid and Y is OH or at least one amino acid, and R is an amino acid selected from Ser, Syc, Thr or other amino acid, said peptide having cell attachment promoting activity, and said peptide not being a naturally occurring peptide; and

providing free cells for attachment to said substrate.

7. A method of promoting cell attachment to a substrate, comprising the steps of:

immobilizing on the substrate a composition of matter comprising a polypeptide

X-Arg-Gly-Asp-R-Y

wherein X is H or at least one amino acid and Y is OH or at least one amino acid, and R is an amino acid selected from Ser, Cys, Thr or other amino acid such that said peptide has cell attachment promoting activity, said polypeptide having less than about 31 amino acid residues; and

providing free cells for attachment to said substrate.

8. A substantially pure peptide including as the cell-attachment-promoting constituent the amino acid sequence Arg-Gly-Arg-R wherein R is Ser, Cys, Thr or other amino acid, said peptide having cell-attachment-promoting activity, and said peptide not being a naturally occurring peptide.

9. A composition of matter comprising the peptide of claim 8 attached to a substrate.

10. A peptide including as the cell-attachment-promoting constituent the amino acid sequence Arg-Gly-Asp-R, wherein R is Ser, Cys, Thr or other amino acid such that the peptide has cell-attachment-promoting activity, wherein said peptide has less than about 31 amino acid residues.

11. A composition of matter comprising the peptide of claim 10 attached to a substrate.

* * * * *

EXHIBIT A

S 44
Rev. 07/89)

CIVIL COVER SHEET

he JS-44 civil cover sheet and the information contained herein neither replace nor supplement the filing and service of pleadings or other papers as required by law, except as provided by local les of court. This form, approved by the Judicial Conference of the United States in September 1974, is required for the use of the Clerk of Court for the purpose of initiating the civil docket eet. (SEE INSTRUCTIONS ON THE REVERSE OF THE FORM.)

(a) PLAINTIFFS
TELIOS PHARMACEUTICALS, INC., a Delaware corporation, and
THE B URNHAM INSTITUTE, a California nonprofit corporation

DEFENDANTS
MERCK KGaA, a German corporation,
THE SCRIPPS RESEARCH INSTITUTE, a California corporation, DR. DAVID A. CHERESH, a Calif o rnia citizen, and DOES 1-25 inclusive

b) COUNTY OF RESIDENCE OF FIRST LISTED PLAINTIFF San Diego
(EXCEPT IN U.S. PLAINTIFF CASES)

COUNTY OF RESIDENCE OF FIRST LISTED DEFENDANT _____
(IN U.S. PLAINTIFF CASES ONLY)
NOTE: IN LAND CONDEMNATION CASES, USE THE LOCATION OF THE TRACT OF LAND INVOLVED

(c) ATTORNEYS (FIRM NAME, ADDRESS, AND TELEPHONE NUMBER)
Mauricio A. Flores, Esq.
CAMPBELL & FLORES LLP
4370 La Jolla Village Drive, Suite 700
San Diego, CA 92122
Tel. (619) 535-9001

ATTORNEYS (IF KNOWN)

'96 1 [illegible]

I. BASIS OF JURISDICTION (PLACE AN x IN ONE BOX ONLY)

- ☐ 1 U.S. Government Plaintiff
- ☒ 3 Federal Question (U.S. Government Not a Party)
- ☐ 2 U.S. Government Defendant
- ☐ 4 Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES (For Diversity Cases Only)

(PLACE AN x IN ONE BOX FOR PLAINTIFF AND ONE BOX FOR DEFENDANT)

	PTF	DEF		PTF	DEF
Citizen of This State	☐ 1	☐ 1	Incorporated or Principal Place of Business in This State	☐ 4	☐ 4
Citizen of Another State	☐ 2	☐ 2	Incorporated and Principal Place of Business in Another State	☐ 5	☐ 5
Citizen or Subject of a Foreign Country	☐ 3	☐ 3	Foreign Nation	☐ 6	☐ 6

V. CAUSE OF ACTION (CITE THE U.S. CIVIL STATUTE UNDER WHICH YOU ARE FILING AND WRITE A BRIEF STATEMENT OF CAUSE. DO NOT CITE JURISDICTIONAL STATUTES UNLESS DIVERSITY)

Suit for Patent Infringement per 35 U.S.C. Section 271.

I. NATURE OF SUIT (PLACE AN x IN ONE BOX ONLY)

CONTRACT
- ☐ 110 Insurance
- ☐ 120 Marine
- ☐ 130 Miller Act
- ☐ 140 Negotiable Instrument
- ☐ 150 Recovery of Overpayment & Enforcement of Judgment
- ☐ 151 Medicare Act
- ☐ 152 Recovery of Defaulted Student Loans (Excl. Veterans)
- ☐ 153 Recovery of Overpayment of Veteran's Benefits
- ☐ 160 Stockholders' Suits
- ☐ 190 Other Contract
- ☐ 195 Contract Product Liability

REAL PROPERTY
- 210 Land Condemnation
- 220 Foreclosure
- 230 Rent Lease & Ejectment
- 240 Torts to Land
- 245 Tort Product Liability
- 290 All Other Real Property

TORTS

PERSONAL INJURY
- ☐ 310 Airplane
- ☐ 315 Airplane Product Liability
- ☐ 320 Assault, Libel & Slander
- ☐ 330 Federal Employers' Liability
- ☐ 340 Marine
- ☐ 345 Marine Product Liability
- ☐ 350 Motor Vehicle
- ☐ 355 Motor Vehicle Product Liability
- ☐ 360 Other Personal Injury

PERSONAL INJURY
- ☐ 362 Personal Injury—Med Malpractice
- ☐ 365 Personal Injury—Product Liability
- ☐ 368 Asbestos Personal Injury Product Liability

PERSONAL PROPERTY
- ☐ 370 Other Fraud
- ☐ 371 Truth in Lending
- ☐ 380 Other Personal Property Damage
- ☐ 385 Property Damage Product Liability

CIVIL RIGHTS
- ☐ 441 Voting
- ☐ 442 Employment
- ☐ 443 Housing/ Accommodations
- ☐ 444 Welfare
- ☐ 440 Other Civil Rights

PRISONER PETITIONS
- ☐ 510 Motions to Vacate Sentence
- Habeas Corpus:
- ☐ 530 General
- ☐ 535 Death Penalty
- ☐ 540 Mandamus & Other
- ☐ 550 Other

FORFEITURE/PENALTY
- ☐ 610 Agriculture
- ☐ 620 Other Food & Drug
- ☐ 625 Drug Related Seizure of Property 21 USC 881
- ☐ 630 Liquor Laws
- ☐ 640 R.R & Truck
- ☐ 650 Airline Regs
- ☐ 660 Occupational Safety/Health
- ☐ 690 Other

LABOR
- ☐ 710 Fair Labor Standards Act
- ☐ 720 Labor/Mgmt. Relations
- ☐ 730 Labor/Mgmt. Reporting & Disclosure Act
- ☐ 740 Railway Labor Act
- ☐ 790 Other Labor Litigation
- ☐ 791 Empl. Ret. Inc. Security Act

BANKRUPTCY
- ☐ 422 Appeal 28 USC 158
- ☒ 423 Withdrawal 28 USC 157

PROPERTY RIGHTS
- ☐ 820 Copyrights
- ☒ 830 Patent
- ☐ 840 Trademark

SOCIAL SECURITY
- ☐ 861 HIA (1395ff)
- ☐ 862 Black Lung (923)
- ☐ 863 DIWC/DIWW (405(g))
- ☐ 864 SSID Title XVI
- ☐ 865 RSI (405(g))

FEDERAL TAX SUITS
- ☐ 870 Taxes (U.S. Plaintiff or Defendant)
- ☐ 871 IRS—Third Party 26 USC 7609

OTHER STATUTES
- ☐ 400 State Reapportionment
- ☐ 410 Antitrust
- ☐ 430 Banks and Banking
- ☐ 450 Commerce/ICC Rates/etc.
- ☐ 460 Deportation
- ☐ 470 Racketeer Influenced and Corrupt Organizations
- ☐ 810 Selective Service
- ☐ 850 Securities/Commodities/ Exchange
- ☐ 875 Customer Challenge 12 USC 3410
- ☐ 891 Agricultural Acts
- ☐ 892 Economic Stabilization Act
- ☐ 893 Environmental Matters
- ☐ 894 Energy Allocation Act
- ☐ 895 Freedom of Information Act
- ☐ 900 Appeal of Fee Determination Under Equal Access to Justice
- ☐ 950 Constitutionality of State Statutes
- ☐ 890 Other Statutory Actions

I. ORIGIN (PLACE AN x IN ONE BOX ONLY)

☒ 1 Original Proceeding ☐ 2 Removed from State Court ☐ 3 Remanded from Appellate Court ☐ 4 Reinstated or Reopened ☐ 5 Transferred from another district (specify) ☐ 6 Multidistrict Litigation ☐ 7 Appeal to District Judge from Magistrate Judgment

II. REQUESTED IN COMPLAINT:

CHECK IF THIS IS A CLASS ACTION ☐ UNDER F.R.C.P. 23

DEMAND $

Check YES only if demanded in complaint:
JURY DEMAND: ☒ YES ☐ NO

III. RELATED CASE(S) IF ANY (See instructions):

JUDGE _____ DOCKET NUMBER _____

TE
July 18, 1996

SIGNATURE OF ATTORNEY OF RECORD

ITED STATES DISTRICT COURT

United States District Court

SOUTHERN DISTRICT OF CALIFORNIA

TELIOS PHARMACEUTICALS, INC., a Delaware corporation, and
THE BURNHAM INSTITUTE, a California nonprofit corporation,

Plaintiffs,

vs

MERCK KGaA, a German corporation, THE SCRIPPS RESEARCH INSTITUTE, a California corporation, DR. DAVID A. CHERESH, a California citizen, and DOES 1-25 inclusive,

Defendants.

SUMMONS IN A CIVIL ACTION

Case No. 961307 K AJB

TO: (Name and Address of Defendant)

YOU ARE HEREBY SUMMONED and required to file with the Clerk of this Court and serve upon PLAINTIFF'S ATTORNEY

CAMPBELL & FLORES LLP
Mauricio A. Flores, Esq.
Lynne M. Brennan, Esq.
Calvin A. Fan, Esq.
4370 La Jolla Village Drive, Suite 700
San Diego, California 92122

An answer to the complaint which is herewith served upon you, within 20 days after service of this summons upon you, exclusive of the day of service. If you fail to do so, judgment by default will be taken against you for the relief demanded in the complaint.

Roberta Westdal
CLERK

SEAL

JAMIE PONCE

BY DEPUTY CLERK

7/18/96
DATE